PANCAM MULTISPECTRAL AND APXS CHEMICAL EXAMINATION OF ROCKS AND SOILS IN MARATHON VALLEY AND POINTS SOUTH ALONG THE RIM OF ENDEAVOUR CRATER. W.H. Farrand[1] , J.R. Johnson[2], J.F.Bell III[3], D.W. Mittlefehldt[4], R. Gellert[5], S. VanBommel[5], R.E. Arvidson[6], C. Schröder[7]. [1]Space Science Institute, 4750 Walnut St., #205, Boulder, CO 80301, farrand@spacescience.org, [2]Applied Physics Lab, Johns Hopkins University, Laurel, MD. [3]Arizona State University, Tempe, AZ, [4]NASA Johnson Space Center, Houston, TX, [5]University of Guelph, Guelph, ON, Canada, [6]Washington University, St. Louis, MO, [7]University of Stirling, Stirling, UK.

Introduction: The Mars Exploration Rover Opportunity has concluded its exploration of Marathon Valley, a 100 m wide valley in the western rim of the 22 km diameter Endeavour crater [1]. Orbital observations from CRISM indicated the presence of Fe smectites [2,3] in Marathon Valley. Since leaving the valley, Opportunity has been traversing along the inner rim of the crater, and currently towards the outer rim. This presentation describes the Pancam 430 to 1009 nm (VNIR) multispectral reflectance and APXS chemical compositions of rock and soil units observed during the latter portions of the Marathon Valley campaign on the Knudson Ridge area and observations of those materials along the traverse to the south.

Pancam and APXS Data: Full Pancam spectral coverage of rock targets consists of 13 filter (13f) data collections with 11 spectrally unique channels with data processing as in [4]. Data were examined using spectral parameters, decorrelation stretch composites, and spectral mixture analysis [e.g., 5,6]. Note that color terms used here refer to colors in various false-color renditions, not true colors. The Alpha Particle X-ray Spectrometer (APXS) determines major and select trace element compositions of targets [e.g., 7].

Lithologic Units: The rocks of Marathon Valley belong to the Shoemaker formation, a clast-bearing impact breccia [8]. Observations of this unit to the north of Marathon Valley revealed differences in the 13f spectra between fracture zones and the non-fractured portions of the rim [6,9] with the matrix of Shoemaker formation outcrop having higher 535 and 904 nm band depths within fracture zones relative to outside of the fracture zones. The rocks on the floor of Marathon Valley did not adhere to this pattern, but were instead more variable with much of the Shoemaker matrix materials being spectrally flat, or convex, in the Pancam NIR bands. There were exceptions such as the Pvt. John Potts target on Knudson Ridge. The abraded surface of this target displayed a spectrum with features attributable to red hematite (high 535 nm band depth, positive 754 to 904 nm slope) (**Fig. 1**).

Red Zones and Disturbed Soils: A characteristic feature of the floor of Marathon Valley, first observed in the Spirit of St. Louis craterform outside of the valley, were curvilinear zones with fragmented rocks appearing red in left eye Pancam composites such as the L2, 5, and 6 (753, 535, 482 nm) bands. These zones were also chemically distinct, with elevated Al and Si and depleted in Fe [10]. In terms of their Pancam spectra, these zones displayed an elevated 535 nm band depth and a convex NIR shape with a negative 934 to 1009 slope- possibly attributable to bound or adsorbed water (**Fig. 2B**).

A notable target of interest observed to the west of Knudson Ridge was a scuffed area within a red zone. A decorrelation stretch composite of the L3, 5, and 7 bands (673, 535, 432 nm) showed yellow soil within the scuff and small yellow pebbles with a 800 nm band (**Fig. 2B**). The 800 nm feature resembled that observed in Fe sulfate-bearing soils observed by the Spirit rover in the Inner Basin south of Husband Hill [5]. APXS observations of the soil (E. Cann) and pebble (Joseph Field) targets confirmed elevated Fe and S.

Data collected by Opportunity demonstrate that low water/rock alteration of Shoemaker formation on the floor of Marathon Valley led to the Fe smectite formation detected by CRISM. The red zones appear to result from higher water/rock ratio alteration.

South of Marathon Valley: A notable target observed in Opportunity's traverse to the south was Spirit Mound, a positive relief feature thought to be stratigraphically lower than Marathon Valley outcrops. Spirit Mound consists of Shoemaker formation breccias, but contains a light-toned band near the base named Gasconade (**Fig. 3**). This band had low 535 nm band depth, a convex NIR shape and a distinctly negative 934 to 1009 nm slope. Rocks in the band are of two compositional groups; one with elevated Ca and S, and one with elevated Si and low Fe (**Fig. 4**). Rocks of the first group are chemically distinct from $CaSO_4$-vein targets observed on Endeavour rim. Evidence for multiple episodes of alteration, or a shift in fluid composition, are consistent with results from elsewhere on the rim of Endeavour [11,12].

Conclusions: The changes in reflectance and chemistry of light-toned outcrop, such as that in Marathon Valley, are consistent with aqueous alteration. Higher water/rock ratio alteration would be required for alteration of the red zones, the Fe sulfate materials revealed

in the red zone scuff, and the light-toned Gasconade target on Spirit Mound.

References: [1] Arvidson, R.E. et al. (2017) LPSC 48, submitted [2] Wray, J.J. et al. (2009) *GRL*, 36, doi: 10.1029/2009GL040734. [3] Fox, V.K. et al. (2016) [4] Bell, J.F. III et al. (2006) *JGR*, 111, doi:10.1029/2005JE002444. [5] Farrand, W.H. (2014) *JGR*, 119, doi:10.1002/2014JE004641. [6] Farrand, W.H. et al. (2016) *Am. Min.*, 101, 2005. [7] Gellert, R. et al. (2006) *JGR*, 111, doi: 10.1029/2005JE002555. [8] Crumpler, L.S. et al. (2015) *JGR*, 120, doi:10.1002/2014JE004699. [9] Farrand, W.H. et al. (2015) *Mars 8*, #1354. [10] Mittlefehldt D.W. et al. (2016) GSA Abs doi:10.1130/abs/2016AM-283470. [11] Arvidson R. E. et al. (2014) Science, 343, doi: 10.1126/science.1248097. [12] Clark B. C. et al. (2016) Am. Min., 101, 1515-1526.

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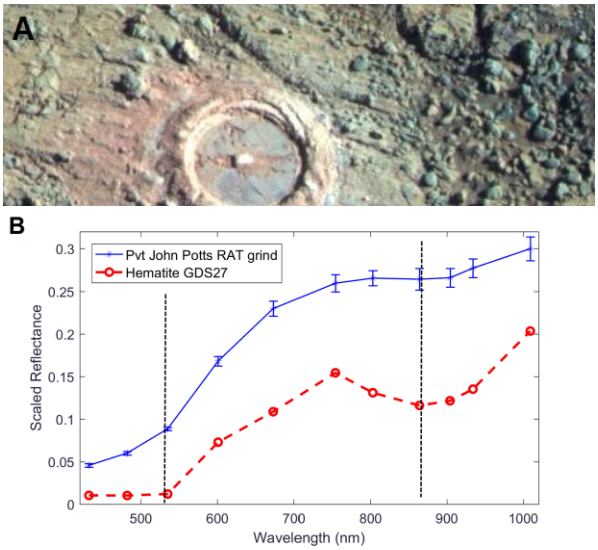
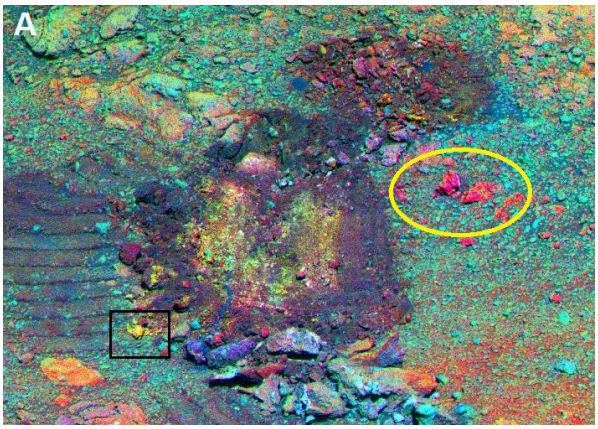


Fig. 1. A. L357 (673, 535, 432 nm) composite of sol 4268 P2546 Pvt. John Potts RAT grind. **B.** Pancam spectra of undisturbed and ground surfaces. Dashed lines indicate distinctive bands at 535 and 864 nm.



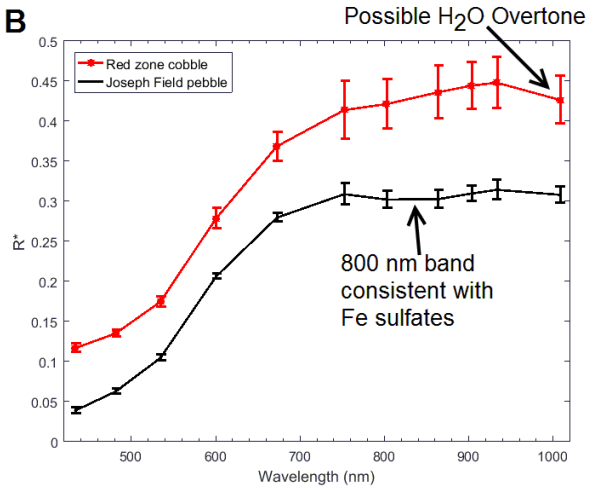


Fig. 2. **A**. Sol 4379 P2583 L357 decorrelation stretch of red zone scuff. **B**. Pancam spectra of red zone cobbles (circled in yellow in **Fig. 3A**) and yellow pebble Joseph Field (in box in **Fig. 3A**).

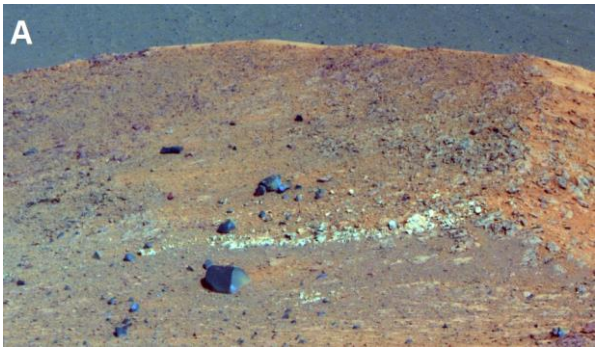


Fig. 3. **A**. Sol 4501 stand-off L256 view of Spirit Mound.

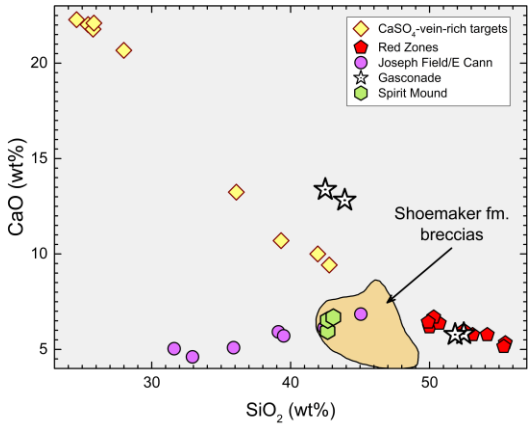


Fig. 4. APXS determined CaO vs. SiO_2 for measurements made on Red Zones, the red zone scuff, and Gasconade at Spirit Mound.